Light and Lighting

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The Choice of Colours

THE selection of colours for decoration is of vital interest in relation to lighting. The illuminating engineer is already becoming more a "brightness engineer" interested not only in the lighting equipment and the resultant foot-candles, but also in the nature of surfaces on which the light is to fall.

He habitually prefers light tints, which reflect light well, but is still diffident in offering advice in regard to choice of colours, —considering apparently that such questions of *taste* do not come within his province. The odd thing is that architects likewise look askance when this query is put to them!

Is it really impracticable to give the public simple advice on this point? One would have thought that such points as the avoidance of crude masses of vivid colour, and the selection of hues (usually near complementary) which harmonise well would be conceded by all enlightened opinion, at least when one is concerned with a scheme to give enduring satisfaction, not some special and spectacular effect.

Education in Illuminating Engineering

Mention was made in our last issue of courses in illuminating engineering which have been arranged to take place in London commencing in September next. We now hear that similar arrangements are being made in the provinces, and we understand that a course has been arranged at the Central Technical College, Birmingham, for students wishing to take the intermediate examination of the City and Guilds in May, 1948.

Other Centres have also been active in this respect. A course extending over two evenings a week is being considered by the Leeds College of Technology, and intending candidates should communicate with the Principal of that college without delay. It is also possible that courses may be arranged on lines somewhat similar to the London courses at the Manchester College of Technology and the City Technical School, Liverpool.

Very successful courses have been arranged in the past at the Stow College School of Engineering, Shamrock-street, Glasgow, by Mr. F. M. Hale, of the Corporation Lighting Department. Provided sufficient support is forthcoming it is intended to run a further course, beginning in September next, the fee for the course being ten shillings.

Preliminary arrangements have also been made for a special course at the Cardiff Technical College. Students would attend on one half-day and one evening per week for two sessions, each of which will extend from September until April, the intermediate examination to be taken in May, 1949. The fee for this course will be in the order of 50s. per session. The number of students will be limited to 20, and those wishing to apply for this course should communicate with the Hon. Secretary of the Cardiff Centre, Mr. N. D. Houston, at 54, St. Mary-street, Cardiff, as soon as possible.

Though the demand for courses throughout the country for the intermediate examination has only recently made itself felt, it is apparent that there is already some call for courses for those wishing to take the final examinations, a demand which will no doubt increase when more people have taken the intermediate examination.

National Physical Laboratory

Annual Visit

On June 18-20 the National Physical Laboratory reverted to pre-war practice by arranging a three-day series of visits to the laboratory when there were many interesting things on view. The weather was not too kind on the opening day, but improved afterwards. From the standpoint of this journal, interest centres chiefly in the building devoted to illumination and photometry—incidentally, one could not but note the convenience of housing all this in one building, instead of scattering it in a number, as was the case originally.

A prominent object in the laboratory is the 10 ft. integrating sphere, in which tests of standard fluorescent tubes were in progress. It appears that the standard 4 ft. and 5 ft. tubes can be measured quite satisfactorily in a globe of this size, but the problem will become difficult if lamps of still greater lengths are introduced; in the case of systems of tubing completely encircling a room it is naturally impossible to measure the unit as a whole, and one has to define its performance in terms of candle-power per foot run.

Other apparatus of interest included the adaptometer, designed to test night vision for the Admiralty during the war. This consists of a small glow lamp with frosted globe, provided with a series of circular apertures of graded diameter, through which light illuminates a sheet of diffusing glass. The brightness of this sheet (of the order of one-millionth of a foot-lambert) can be varied within wide limits, and in tests was used as a background for a small object which the observer had to distinguish.

Elsewhere in the laboratory, Dr. Stiles had an exhibit illustrating his apparatus for a special research now in progress which has for its object the study of the effect of surrounding fields of different colours on the perception of coloured test fields. This has already led to interesting and curious results concerning the different retinal mechanisms involved in the perception of coloured light. These results were ingeniously illustrated by the projection on the screen of graphs in white, red, green, and blue, which could be moved independently, so as to show the course of the visual response to lights of different colours at different intensities.

The photometry of discharge lamps is at present being done visually because of the great difference between the spectral distribution of these lamps and that of the tungsten filament standards. Work is now in progress to establish a photoelectric method for the accurate measurement of such lamps.

Light Diffusing Qualities of Magnesium Oxide

A research on this subject by V. G. W. Harrison (of the Printing and Allied Trades' Research Association), reprinted from the Proceedings of the Physical Society, brings out the fact that in general Lambert's Law does not hold, even for a surface of magnesium oxide 2 mm. thick. Above 60° distribution curves become irregular and cannot be expressed in terms of any simple equation, and above 75° incidence signs of specular reflection appear. Actually 45° is the only angle for which Lambert's Law, in its simpler form, does apply. This is also a convenient angle from the standpoint of instrument design. There is good ground for the suggestion, therefore, that this should be adopted as a standard angle in testing gloss—a matter of considerable interest in relation to ease of reading from more or less shiny papers.

Are Windows Really Necessary? *

In view of the discussion now proceeding in regard to the desirability of omitting windows from factories in general, the experience in one special case, that of the Liverpool Gas Company, mentioned in the "Gas World" for June 21 and summarised in what follows, is of considerable interest.

The Liverpool Gas Company has adopted the policy of bricking up all unnecessary windows, and has decided that when new buildings are erected windows will be eliminated. It is regarded as doubtful whether architects can improve the appearance of gas works buildings by including inefficient window space. Moreover, windows in present buildings are only too often completely covered with dirt, are broken, or are obscured by more recent structures or machinery.

In general, it is considered that windows are not necessary for adequate ventilation, though they may be, under certain circumstances, to give light. In the great majority of buildings in a gasworks, however, it is thought that far more accurate work can be carried out under scientifically designed artificial lighting than with light which is dependent on the whims of the sun or the window cleaner.

Other very sound arguments for the exclusion of daylight are that very often continuous artificial lighting is required to maintain working conditions in rooms already "lighted" by windows; windows invariably dictate the position of plant or furniture; and in the case of a gasworks, though this argument might apply equally well to a number of other industrial processes, gas-making is a 24-hour process, so that windows are useless for many hours per day in any case.

The advantages of banishing windows are thought to outweigh the disadvantages, the chief of which are: possibility of breakdown in lighting supply, possible increase in cost of artificial lighting, and the cost of air conditioning, if this is installed.

* It is understood that a debate, having an important bearing on this subject, has been suggested for inclusion in the programme of the I.E.S. for the Session 1947-48.

Cold Cathode Lighting

On pp. 127-129 of this issue we summarise a contribution on the above subject by Mr. C. Dykes Brown, which recently appeared in the "Osram Bulletin." This form of lighting was already becoming familiar in this country before the war, but subsequent events naturally impeded its development, and it is only now coming into its own again. In the meantime there has been very rapid progress in the United States, where, no doubt, the handicaps imposed by the war were less serious. An indication of the interest taken in this subject is to be found in the existence of a new organisation, the Fluorescent Lighting Association, which has recently announced the holding of the first of a series of annual exhibitions to take place in New York in October next. Features will be the display of the latest forms of equipment, protective devices, and architectural materials for use in connection with this form of lighting being on view, in addition to the actual lamps and lighting accessories. The exhibition will also serve to illustrate the degree of standardisation already achieved in this field.

Engineering and Marine Exhibition

In our May issue (p. 82) we referred to the invitation extended to I.E.S. members to visit the above exhibition on Tuesday, September 9. We are asked to say that tickets for the use of members on that date are now available and can be obtained on application to I.E.S. Headquarters at 32, Victoria-street, London, S.W.1.

Prospects of Improved Street Lighting

Looking back to August, 1944, when a meeting was called at the Home Office to discuss a relaxation in the black-out, it is disappointing to note how imperfectly the hope then expressed of "a progressive improvement towards full lighting of our streets" has been fulfilled. Only a short time ago the I.E.S. President, speaking at the Society's annual dinner, recalled that the first action taken by the Ministry of Transport after assuming responsibility for public lighting was to call for general extinction after midnight, and, although this proposal has not been literally followed, our streets remain pools of stygian gloom as a concession to the general call for fuel economy. The "Gas World," in commenting upon this matter, quotes the recent announcement of June 20 that the present black-out will cease with the termination of double summer time on August 10. From that date local authorities will be allowed to resume direct lighting to a maximum of 50 per cent. of the pre-war level, which is something to be thankful for. The method of fulfilling this condition, whether by fully lighting main streets and leaving side streets in darkness, or by spreading reduced lighting over the whole area, will apparently be left to the discretion of each authority. It is here that the judgment of the public lighting engineer will tell. There is apparently little hope of the restoration of shop-window lighting during the winter season—a loss which not only impedes trading but is very largely responsible for the gloomy appearance of urban streets.

No Lamps in New Streets?

According to a statement in the Press, the Ministry of Health has laid in down that, for the time being, no lamp standards are to be put up in any new housing estates. Apparently the reason assigned for this step is not fuel economy—though this is possibly in the minds of the authorities—but shortage of materials. As in so many other cases, one cannot help questioning the wisdom of a general rule of this description. If there were an acute shortage of posts and materials in busy traffic streets one could understand that new roads in housing estates might have to go short, but this is hardly the case for existing installations. Certainly the equipment of new roads presents difficulties, but it cannot be gainsaid that new roads, as well as old ones, require light. One would think, therefore, that local public lighting engineers might be left to do their best to meet this need —as in many instances they are actually doing quite successfully.

Mr. C. W. *Sully's Golden Wedding*

I.E.S. members will all wish to congratulate Mr. C. W. Sully on having celebrated his golden wedding on July 14. Mr. Sully was Director of E.L.M.A. from 1922 until early in the war. He was I.E.S. President in 1933, when he took an active part in the development of the Society outside London, paving the way for the formation of Centres, which has been such a feature of subsequent years.

The Unit of Light

An official announcement from the National Physical Laboratory by Sir Charles G. Darwin, K.B.E., M.C., M.A., Sc.D., F.R.S., Director

Following the decision of the International Committee of Weights and Measures, the National Physical Laboratory will, on and after January 1, 1948, express all photometric values in terms of units based on the "*new candle*." This unit of luminous intensity is of such a magnitude that the brightness of a full (or cavity) radiator (black body) at the temperature of solidification of platinum is 60 *new candles* per square centimetre. The *new lumen* is the luminous flux radiated within unit solid angle by a uniform source having a luminous intensity of one *new candle*. The new unit of illumination will be one *new lumen* per unit area. One *new lumen* per sq. ft. will also be called one *new foot-candle* and one *new lumen* per sq. metre one *new lux*. The new unit of brightness will be one *new candle* per unit area, and, alternatively, one *new foot-lambert*. The latter unit is defined as the brightness of a perfectly diffusing surface of 100 per cent reflexion factor when its illumination is one *new lumen* per square foot.

When differences of colour are involved in the determination of any magnitude in terms of the above units, the evaluation will be in accordance with that which would be obtained by an observer having the relative luminosity curve (curve connecting eye sensitivity with wavelength) adopted by the International Commission on Illumination in 1924 and later by the International Committee of Weights and Measures.

The differences between the new units and those in use hitherto are small. The present units, based on the "international candle," were introduced on April 1, 1909, in Great Britain, France, and the United States of America and were adopted in 1921 by the International Commission on Illumination. Nevertheless, Germany and some Central European countries continued to use units based on the Hefner candle (about 0.9 international candle). The international candle was not based on any primary standard; it was derived from the units defined in terms of the old flame standards and was maintained by means of carbon and tungsten filament electric lamps. Further, the values of the unit at different colour temperatures did not exactly agree, when compared on the basis of the international relative luminosity curve adopted in 1924.

The magnitude of the new unit has been so chosen that it will introduce only very small changes (less than 0.5 per cent.) in the values of luminous intensity assigned to lamps operating at a colour temperature of about 2360°K. For lamps at considerably higher colour temperatures, e.g., ordinary gas-filled electric lamps at normal efficiencies, the values expressed in terms of the *new candle* will be several per cent. lower than those expressed in international candles. At the colour temperature of the primary standard (2046°K), values in terms of the *new candle* are about 1.7 per cent. higher than those in terms of the international candle.

On account of this alteration in the basis on which sources of light of different colours are compared, it is impossible to give a factor for converting values in international candles to values in *new candles*.

Eyesight and Lighting

Report of a discussion by the Ophthalmological Section of the Royal Society of Medicine.

An interesting meeting of the ophthalmological section of the Royal Society of Medicine was held at the society's headquarters in Wimpole-street on June 12, 1947, when a discussion on illumination was opened by Mr. J. G. Drummond Currie, F.R.C.S., Dr. J. W. T. Walsh, and Mr. H. C. Weston. The meeting was well attended by ophthalmologists, among whom were Prof. Ida Mann and Mr. Frank Law, F.R.C.S., the hon. secretary of the Faculty of Ophthalmologists. A number of I.E.S. members were also present.

Preliminary to the discussion an exhibition with demonstrations was arranged by the General Electric Co. The exhibits were designed chiefly to show the construction and operation of the fluorescent lamp, and the special characteristics of fluorescent lighting, as well as some of its applications. The fluorescent operating theatre unit displayed was the highlight of the exhibition, in both senses of the expression, but all the exhibits were viewed with great interest, and there is no doubt that the ophthalmologists present found them instructive and the demonstrators most informative.

Mr. Drummond Currie, who is a well-known Cheltenham ophthalmologist and a member of the I.E.S., was the first speaker. He gave an interesting account of the development of artificial light sources, pointing out the advantages of historically successive types of lamps, and dealing in some detail with the most recent and remarkable type—the fluorescent lamp. He explained how fluorescence of the powders lining the lamp is excited, and pointed out that although some people seemed to think that harmful ultra-violet radiation is emitted by fluorescent lamps there need, in fact, be no anxiety on this score. As to the stroboscopic effect, this might be troublesome in certain circumstances unless the installation was suitably planned, but he thought the importance of this effect had been much exaggerated. He had met with no complaints of stroboscopic difficulties in his experience as consulting ophthalmologist to a large organisation manufacturing precision instruments. He had found some workers who said they did not like fluorescent lighting, and he thought their objections could only have a psychological basis. However, if bare lamps are installed flicker may be noticed peripherally and so give rise to complaints. Finally, he emphaised that lighting does not consist merely in providing a blaze of light. The correct location of light sources, and all the other factors which affect the quality of lighting, are very important and should be duly considered.

Brightness and Illumination

Following Mr. Currie, Dr. Walsh dealt with the definition and measurement of brightness and illumination. It has sometimes been said, he began, that the illuminating engineer should more properly regard himself as a brightness engineer. It is argued that what the eye appreciates is brightness and not illumination. On the other hand, the engineer is in two difficulties if he tries to design for brightness. In the first place, the brightness of an object, measured by a photometer, depends partly on the illumination and partly on the reflection characteristics of the object, and these are usually quite out of the illuminating engineer's control. Even worse than this is the fact that the photometer does not tell the whole story. The word "brightness" as it is commonly used may mean either of two things; as used by the engineer it generally denotes the quantity which the photometer measures, whilst it is also frequently used to denote one attribute of the sensation produced when an object is looked at, viz., that attribute by means of which object may be arranged in a series of increasing or decreasing brightness.

In discussing the subject from the points of view of the illuminating engineer and the ophthalmologist, it is necessary to draw a clear distinction between these two meanings associated with the same word. In fact, it is desirable to qualify the word by an adjective which shows clearly which meaning is

intended. For the engineering and physical meaning the term "photometric brightness" may be used, the term "subjective brightness" being employed whenever the sensation is meant.

Dr. Walsh then went on to explain various terms used in the measurement of illumination and photometric brightness and to some consideration of the visual and photometric instruments used.

Artificial Light and the Eye

Mr. Weston then dealt briefly with the illumination requirements of the eye, and with some misconceptions concerning artificial lighting. The view is still often expressed, he said, that artificial light is not good for the eyes, at any rate, if one has to rely upon it for long periods. One of the reasons advanced for this belief is that artificial light differs qualitatively and visibly from natural light. The spectral composition of the light given by artificial sources now commonly used is not identical with that of daylight, which is itself subject to variations of colour quality. Nevertheless, most of these sources give what is broadly called "white" light, and it has never been shown that healthy eyes suffer any harmful effects which can be attributed to the "make-up" of the luminous flux emitted by such sources.

The now widely used fluorescent lighting, although generally very popular, has given rise to some complaints of ill-effects, as well as to some ill-considered speculations concerning the harm it might do. Most of the complaints he had personally investigated had been vaguely expressed, and external signs of ocular disturbance were generally absent. Most of the complaints came from people found to be working with low illumination, and badly planned installations are certainly responsible for some cases of dissatisfaction.

Fears have been expressed concerning the effects of ultra-violet radiation emitted by fluorescent lamps, but there is none of shorter wavelength than is present in diffuse daylight, and its intensity at ordinary levels of illumination appears to be much less than is believed to be necessary for an abiotic action.

Artificial light is not bad for the eyes on account of any qualitative dissimilarity to daylight, but it is very often bad for them because there is not enough of it, and the eyes are therefore required to operate too long at a distance which involves an undue muscular effort for accommodation and convergence. The question thus arises, "How much illumination is necessary for the performance of different visual tasks efficiently and without eyestrain?"

Illumination Requirements

There are several possible ways, the speaker said, of getting an answer to this question. One way is to ascertain what, on the average, is the illumination currently used for different purposes. This method has obvious shortcomings. It does not necessarily indicate the real need of the user for there was always a general tendency to exercise "economy" in artificial lighting. When practice is freely determined people who have really fine work to do often choose very high illuminations.

Another way is to determine, experimentally, the level of illumination at which the performance of particular visual tasks come to a maximum. By this means, the optimum illuminations have been found for some specific occupations.

A third method consists in analysing the particular objects involved in any given task and appraising them in respect of certain characteristics, whose magnitudes determine the visual capacities required to see the objects easily. The principal characteristics concerned are the size and distance of the details that need to be distinguished, as well as the reflectivity of these details and of their immediate surrounds. Then — from what is known concerning the way in which visual performance varies with variation of size, contrast and illumination—a value of the latter can be found which will be appropriate for the task considered. The use of this method has been simplified, as far as possible, by the charts, and explanatory notes given in the Illuminating Engineering Society's Lighting Code.

The I.E.S. Code

A point to notice particularly is that the illumination values in the Code are

in geometrical or ratio scales. The reason for this is that successively larger increments of illumination are necessary to increase visual capacity step by step, just as they are to produce, successively, an apparent difference of brightness. In other words, illumination should be increased in *proportion* to its value at the beginning of each step, rather than by equal increments, which would become progressively less effective; just as an increment of £10 when income is £1,000 per annum would be far less satisfying than it would when income is only £100 per annum.

The proportional increase upon each value to the next above it in the I.E.S. scales is not strictly constant, simply because to make it so would lead to inconvenient fractional values. The average increment, however, is one of nearly 50 per cent., and, in practice, it is difficult to discriminate between visual tasks for which any smaller relative difference of illumination would be appropriate. Mr. Weston then took as examples three practical visual tasks, and explained how the appropriate illuminations could be found from the charts.

In conclusion, he said that, in view of the growing proportion of the working population distributed in the older age groups, the standard of vision that must be taken as the average is becoming lower. The effect of this upon industrial productivity may be more serious than might be supposed, unless standards of illumination are improved and a more extensive use is made of other aids to vision.

After the opening papers Mr. J. M. Waldram showed two short films illustrating common visual tasks. One of these dealt with the operation of needle-threading, some of the "shots" being photographed by a suitable technique exactly as seen by the person threading the needle whilst the operation was in progress. The second film dealt with lathe turning, and in, his commentary, Mr. Waldram drew attention to the detail the operator had to see, and to the way in which the visual task was facilitated by suitably positioning the local light source. These films proved of great interest, and as a sequel to the generalised treatment of task analysis by Mr. Weston, they were most valuable.

Discussion

In the ensuing general discussion a number of interesting points were raised. Several speakers referred to the prevalence of glare, due to exposed light sources and reflection from shiny surfaces. Dr. Sharpley thought that not enough work has been done to determine the effects of glare, and especially its effect upon the output of workers. He wondered whether the size of the fluorescent lamp might sometimes make the avoidance of glare difficult. The need for better lighting for clerical work was stressed by another speaker, who also commented on the fact that the dirtier the work the poorer seemed to be the illumination provided. Dr. Standford thought that the general prevalence of poor lighting influenced publishers in the choice of paper for many of their books, and that, if good lighting is available, an off-white or cream paper, such as is used for some of the more expensive books, is more conducive to visual comfort than a dead-white paper; in any case, glazed paper is bad. Mention was also made of the dissatisfaction with fluorescent lighting sometimes found if the installation is not planned to provide adequate illumination, owing to the impression of failing daylight which can be experienced in these circumstances.

Mr. R. H. BATEY

Mr. R. H. Batey, of the British Thomson-Houston Company, who has been their representative in Middlesbrough since 1940, has now been appointed lighting engineer at their Birmingham office.

Mr. Batey is well known in Middlesbrough, where he was responsible for the formation of the Tees-side Group of the Illuminating Engineering Society, acting also as honorary secretary.

Obituary

Mr. H. Gunner

We record with regret the death of Mr. H. Gunner, who for some 20 years had been the London manager of the Wardle Engineering Company, Ltd., and had been a member of the Illuminating Engineering Society for a similar period.

International Commission On Illumination

Proceedings of the 1939 Meetings

(*Communicated*)

Readers, taking note of the occasional references to the prospective revival of the International Illumination Congress in 1948, may naturally wonder how and where they can get particulars of its last meeting.

It will be recalled that Dr. Halbertsma, the President of the International Commission on Illumination, in his address at the annual general meeting of the Illuminating Engineering Society last May, mentioned the adventures which had befallen the "Proceedings" of the session held in Holland shortly before the outbreak of war.

It will be remembered that, as part of the arrangement for the payment to the Commission of the German subvention to the Commission it was agreed that the "Proceedings" should be printed in Vienna at the cost of the German National Committee. The manuscript was prepared by the Central Bureau in Teddington and was forwarded to Germany for printing. By the time the proofs were ready, war had broken out between this country and Germany, so the proof-reading and further work which had to be supervised by the Bureau was undertaken by Dr. Halbertsma, as President.

Two of the three volumes were dealt with in this way, viz., those containing the papers by individual authors. The third volume, containing secretariat reports, the minutes of the meetings, principal decisions of the Commission, etc., was not completed because decisions of the I.C.I. are provisional for a period of six months, pending ratification by National Committees. However, a copy of the material for this volume, was sent to Holland and at the invasion of that country was concealed in the vaults of the K.E.M.A. laboratory at Arnhem. There it survived all the perils of war and has now been recovered intact and quite undamaged.

The two volumes of which printing was completed were in due course published by the German National Committee and distributed by them to those countries with whom they could establish contact. The supplies for other countries were retained in Vienna and have now happily been found undamaged and despatched to the bureau of the Commission. No doubt they will be distributed to the other National Committees in due course.

The printing of the third volume will, doubtless, now be undertaken by the Bureau of the Commission for the sake of completing the records of the Commission's work, though it is difficult to see how it can appear before the meeting next summer.

Because of the difficulties caused by the non-publication of the official 1939 "Proceedings," the U.S. National Committee prepared, from the documents available to them, a mimeographed volume giving an excellent account of the meetings and technical papers and discussions. A number of these volumes were supplied by the U.S. Committee to other National Committees.

International Organisation For Standardisation

The first meeting of the Council of the International Organisation for Standardisation (known as the I.S.O.) since the ratification of its constitution (which was drafted in London last October at a meeting of 28 nations) was held in Zurich from June 17 to 20. The Council consists of the National Standards bodies of the following countries:—

Australia, Belgium, Brazil, China, France, India, Norway, Switzerland, United Kingdom, U.S.A., U.S.S.R.

The meetings were presided over by Mr. Howard Coonley, of the U.S.A., who was elected President of I.S.O. in London last October.

The Council appointed M. Henri St. Leger to be general secretary, and his office will be situated in Geneva.

An extensive programme of technical work will be submitted to the standards organisations in the different countries for consideration. It is now suggested that the International Electrotechnical Commission (known as the I.E.C.), which has National Committees in 23 countries should affiliate with the I.S.O.

At the meetings of the Council of the I.S.O. representatives from the International Labour Office, the United Nations Educational Scientific and Cultural Organisation, were invited to be present in order to discuss the question of collaboration.

Operation and Maintenance of Cold Cathode Fluorescent Fittings

In what follows we give extracts from an article by Mr. C. Dykes Brown, A.M.I.E.E., which appeared in the *Osram Bulletin* for April, 1947

The rapid expansion in the use of fluorescent discharge lamps has brought about a new lighting era, necessitating not only a specialised knowledge for solving the many lighting problems which arise, but also an intelligent appreciation of the operation of the lamps, especially by those who are actively interested in their installation or maintenance.

Although code cathode fluorescent discharge tubes have been used in this country for lighting installations since the early 1930's, it is only comparatively recently that their popularity has become such that they can be considered in the same category as the more firmly established sources of light.

The increase in their use can be attributed in a large measure to the introduction of self-contained lighting fittings incorporating not only the tubes but also the transformers and high tension connections. Consideration is given in this article to this type of fitting, but much of the data also applies to the type of installation, sometimes referred to as "tailor-made," in which tubes are manufactured and installed to conform to particular architectural features, the transformers in these cases usually being accommodated remote from the tubes.

It is not intended to deal with the physics associated with the operation of these tubes but rather to consider the more practical aspects of the subject which are of interest to installation and maintenance engineers.

Self-contained High Tension Fluorescent Lighting Fittings

The majority of self-contained fittings manufactured now are of simple design and incorporate straight tubes. They have proved very popular for a variety of applications, typical of which is general store lighting. When more decorative fittings are required a unit with curved tubes may be designed along the lines illustrated in Fig. 1. Whichever arrangement is used the tubes usually extend over a length of eight or nine feet, making the unit eminently suitable for situations where a reasonably even intensity is required over a comparatively large area.

A high voltage is necessary to operate the tubes, and in all self-contained

Fig. 1. Decorative effect provided by a curved-tube fluorescent fitting installed at Galeries Lafayette, Ltd., London.

lighting units this is obtained from special transformers which are concealed in part of the fitting. The equipment is suitable for connection to A.C. supplies and a range of transformers is available for specified voltages between 200 and 250. Provision is also made in the fitting for condensers to correct the power factor of the transformers. No additional starting device is required, and the tubes light immediately the transformers are connected to the supply.

The Cold Cathode Fluorescent Tube

The electrodes in the tubes with which we are dealing here are of the cold cathode type, and consist of hollow cylinders about 2 in. long, made of nickel or iron. As the diameter of the electrodes is similar to the luminous portion of the tube it is necessary for the ends of tubes to be of increased size to accommodate them.

As with hot cathode lamps, which operate from mains voltages, a fluorescent powder is applied to the inside surface of the tube. This powder is excited by the ultra violet radiation from the discharge through the gas filling in the tube and a range of colours of varying degrees of warmth is obtained by making use of different powders and gas fillings.

A discharge through low pressure mercury vapour will excite certain powders to provide the well known range of daylight, warm white, and intermediate white. Mercury vapour is also used with other powders to produce many different colours, including blue and green. Where a warm mellow light is required useful colours such as gold and pink can be used, these being obtained by exciting fluorescent powders by a neon discharge.

The voltage drop along the luminous part of the tube between the electrodes is proportional to its length and is different for tubes in which mercury vapour is employed and those with neon filling. Typical values for 20 mm. diameter tubes are given in Table 1. This information refers only to the normal running voltages and does not take into account the higher voltages necessary to initiate the discharge. A further voltage drop occurs at the electrodes; this is also shown in Table 1.

In a typical self-contained unit each of the straight tubes has a luminous section of approximately 8 ft. 9 in. between the electrodes, of which 8 ft. 6 in. is visible and is useful lighting length. By reference to Table 1 it will be seen that a mercury filled tube of this length operating at 120 mA has a running voltage of $(8\frac{1}{2} \times 52) + 195$, or 650 volts. The simplest circuit arrangements are obtained by using three tubes which have similar electrical characteristics and arranging for them to be connected in series.

Transformers and Circuits

The high voltage necessary to start and maintain the discharge is obtained from transformers of the "leakage reactance" type. These are designed to supply the full voltage at no load to enable the tubes to strike and to operate with a reduced secondary voltage as soon as the discharge is established, thus limiting the current through the tubes to a predetermined value.

Instead of providing one transformer for the triple tube unit it is more convenient to use two transformers and employ the circuit shown in Fig. 2. This has the advantage that the transformers can be made small enough to be incorporated in the fitting.

As the running voltage of each tube is 650 a total of 1950 volts is required to operate three tubes in series. By making use of the tandem system of connection each of the two transformers has to supply only half the total voltage or, in other words, must operate with a running voltage of 975. In

TABLE I

	Mercury		Neon
Tube current	60 mA	120 mA	60 mA
Electrode drop in volts	190	195	175
Volts drop per foot of tube	57	52	99

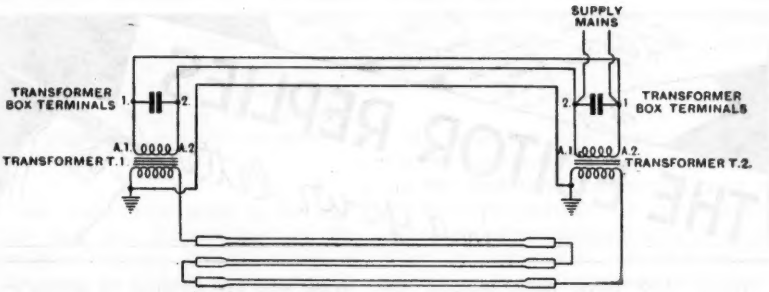


Fig. 2. Most suitable circuit for a triple-tube unit.

practice, these transformers are wound to give an open circuit voltage which allows a margin of safety over and above that normally necessary to "strike" the tubes.

Although the two transformers are electrically and mechanically identical it is essential that they are connected in circuit in such a way that the secondary voltages are 180° out of phase. Reference to Fig. 2 will show that by connecting together similarly numbered terminals of the pair of transformers, the secondary terminal voltages of the two transformers will be opposite in phase. In the event of a unit having two transformers which are not so paired, the tubes will not light if the primary windings are paralleled in the manner described, but correct operation can be obtained by reversing the paralleling leads at one end.

Performance

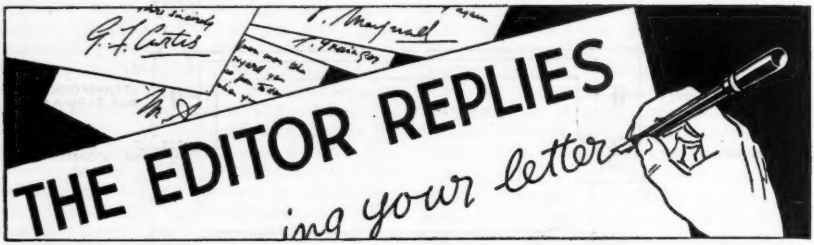
The efficiency at different stages in the life of a typical white fluorescent tube, together with other technical data relevant to triple tube fittings, is shown in Table II.

Small variations in the supply voltage will cause similar changes in the tube current. As the light output is approximately proportional to the tube current, variations in the applied volts will have a directly proportional effect on the resultant intensity. On the other hand, the useful life of the tubes is increased with reduced tube current.

The stroboscopic effect obtained from any form of electric discharge lamp may be detected in cold cathode fluorescent lamps by a critical user, but it is usually found that this can be safely ignored. Should it be necessary to reduce the effect adjacent fittings should be connected to different phases of the supply. With this arrangement it is unlikely that stroboscopic effect will be apparent, providing the fittings are installed so that a good mix of light from fittings on different phases is obtained on the working plane.

TABLE II

F.16993 TRIPLE TUBE UNIT	
Overall length of fitting	9′ 10½″
,, ,, ,, tubes	9′ 6″ ± 1½″
Visible length of tubes	8′ 6″
Diameter of tubes	20 mm.
Tube current	120 mA.
Efficiency of tubes, initial	33 lumens/watt
,, ,, ,, at 100 hours	31 ,, ,,
,, ,, ,, at 6000 hours	22 ,, ,,
,, ,, ,, average over 6000 hours	24 ,, ,,
Surface Brightness	3 candles/sq. in.
Overall tube consumption	210 watts approx.
Overall tranformer losses	40 ,, ,,
Total consumption of fitting	250 watts/approx.
Corrected Power Factor	0.85 approx.



Those who have been making inquiries about **Courses in Illuminating Engineering** will be interested in the note appearing on p. 118 in this issue, showing what the I.E.S. Centres are doing in this respect. The progress revealed is very creditable and shows that a definite demand exists. We advise any I.E.S. members or others interested to get in touch, either with the headquarters of the Society or with the hon. secretary of the nearest Centre.

At present such courses are intended mainly for the intermediate grade of the City and Guilds examination in Illuminating Engineering. But no doubt arrangements will be made in due course for those wishing to take the Final. One difficulty one foresees in this connection, especially if the movement continues to develop, is that of finding a sufficient number of qualified lecturers. Ultimately, I imagine, a **Correspondence Course** for those in country districts unable to attend at any Centre, may be organised.

I am glad to be able to report, on good authority, that substantial progress has been made with the preparation of Dr. Walsh's **Text Book on Illuminating Engineering,** publication of which is expected in the early autumn. In the meantime, as the demand may be considerable, there would be no harm in those who are anxious to secure copies giving advance orders to the publishers (Sir Isaac Pitman and Sons, Ltd., 39, Parker - street, Kingsway, London, W.C.2).

Mr. P. J. Waldram's contribution to our May issue (p. 83) on Industrial Problems of Natural Lighting, has led to some comments. The main question involved—the use of artificial light as a supplement to or instead of **daylight**—is likely to form the subject of an I.E.S. discussion next session. Very few architects, I imagine, would countenance a **reduction of normal window space,** where it is valuable, in view of the installation of artificial lighting, however good. But it is questionable whether (in schools for example), **great expense** should be incurred in trying to secure **excessively high daylight factors,** which artificial lighting might limit. In congested city areas, where daylight is inevitably obstructed by adjacent buildings, there is a good deal to be said for reliance on good artificial lighting, especially fluorescent lighting which mixes with daylight so well.

I believe that, theoretically, the employment of persons in **underground basements** into which no daylight penetrates is now no longer legal. There are, however, many cases for example in

banks where documents and essential work were often transferred underground during the air-raid periods—where continuous work has gone on for months by good artificial lighting without ill effects, though in time workers feel the absence of windows irksome.

A more debateable point is the suggestion that the **lumens per sq. ft.** requisite for carrying on a given task is **not the same for natural as for artificial light.** So far as the effect on the eye of the illumination on the work is concerned I doubt whether there is any substantial difference, provided the spectrum bears a general resemblance to that of daylight. But it is certainly true that the apparent effect of such illumination, whether natural or artificial, may be depressed if the eye is simultaneously exposed to glimpses of bright sunlight or even expanses of sky. From this standpoint one would be inclined to think that higher values are in general needed by daylight than by well-designed artificial light, reasonably free from glare.

A rather interesting question is raised by the reported experience of those concerned with **large blocks of office buildings**—that when a set of offices is vacated the new tenant is rarely content with the existing lighting and prefers to make new arrangements to suit his needs. Indeed—so I have heard—it has become the practice to remove all old wiring and lighting equipment at once in such cases.

Is it really the fact that, with modern office lighting, the nature and position of fittings depends so much upon the needs or the whims of occupants? Or should **good general lighting** continue to answer all needs, even if an office changes hands? If the former is true, evidently the preparation of **detailed codes of practice** would seem rather illusory.

My attention has been drawn to another installation of **fluorescent lighting for escalators,** I understand also on the Bakerloo railway. In this case the ordinary indirect lighting with tungsten lamps is apparently supplemented by fluorescent lamps concealed behind cut-glass panels recessed in the roof. My informant says that, looking upwards the resemblance to daylight is very close—(in fact on consideration he is not quite sure that it is not daylight!) though the addition to the available illumination is not very noticeable.

Colour Temperature of Light Sources

A paper on the colour temperature of light sources was read before the Colour Group of the Physical Society on June 4 by Mr. H. G. W. Harding, of the National Physical Laboratory. The first part of the lecture was devoted to general principles, and the definition of a black-body radiator, a grey-body radiator, and a selective radiator.

The colour temperature scale was based on taking the melting point of gold as 1336°K and then using the Planck radiation formula with the value of the constant C put at 1.432 cm. degs. Temperatures up to 2400°K were measured directly by means of an optical pyrometer, but for higher temperatures it was necessary to use colour filters. Any given filter would convert a temperature θ_1 to another temperature θ_2, where $(1/\theta_1)-(1/\theta_2)$ was a constant for that filter, known as the reciprocal filter step. This step was measured in "mireds," i.e., in $10^6/\theta$ where θ was in degrees. Arising from problems met during the war, there was a demand for a filter which would bridge the step from 2250° to 2850°K (a reciprocal filter step of 94 mireds), and Messrs. Chance Bros. were collaborating with the Admiralty and the National Physical Laboratory in the production of such a glass filter.

Mr. Harding then went on to speak of the difficulty of assigning a colour temperature to light with a spectral distribution which was different from that of a black body at any temperature. Such a light, strictly speaking, had no colour temperature, but nevertheless the convenience of the colour-temperature method of description was so great that it was still used, although the light from the source and that from a black body adjusted to give the best possible match showed a very marked green-purple contrast when viewed side by side in a photometer head.

This was the state of affairs with the fluorescent lamp and it was doubtful whether a colour temperature should be assigned to such sources. Experiments had been made on the differences between normal-sighted observers as regards the temperature of the black-body which they judged to give the best colour match with sources of this kind and the lecturer showed some slides from which it was evident that, except when the departure from the black-body spectral distribution was small, the differences might be considerable.

In conclusion, Mr. Harding referred to the photo-electric method of colour matching, using a photocell with two coloured filters, e.g., a red and a blue, to determine when two lights gave the nearest approach to a colour match.

In the discussion the possible changes which a glass might undergo in course of time were mentioned. Some glasses, according to Mr. Harding, showed quite noticeable changes in the course of a few years. This was stated to depend very much on the composition of the glass; some glasses were much better in this respect than others.

Dr. Wright expressed great interest in the differences between observers when they attempted to match two lights of different spectral distributions. He felt that these might well repay further investigation to see if there was any correlation with the peculiarities of the observers' colour vision.

On the notices announcing this meeting it was stated that, at the suggestion of the Colour Group Committee, Messrs. Wrightman Mountain, Ltd., had produced chromaticity charts printed in black or in green ink on thick and on thin paper and that these charts could now be purchased, being No. 63 in Messrs. Wrightman Mountain's series of data sheets.

Lighting Service

In what follows we present some notes on the contents of the Summer issue of *Lighting Service*, the journal of the Lighting Service Bureau (2, Savoy Hill, London, W.C.2). Any readers who would like to receive complimentary copies of this bulletin should apply to the Bureau at the above address.

The summer edition of *Lighting Service*, the second post-war production, is a bright venture containing much interesting news and comment. As regards matters of organisation we note the tribute to Mr. E. B. Sawyer, whose appointment as manager of the Bureau in London was noticed some time ago, and the installation of Mr. C. K. J. King as Area Engineer for Scotland in succession to Mr. M. W. Hime. One is interested to note that the Scottish Bureau has in mind investigations into mine lighting, on similar lines to those already being carried out in Leeds.

Textile Tests

Of great interest in this connection is the record of recent tests on rayon weaving, extending over periods of four weeks and conducted with both fluorescent and filament lighting. The estimated increase in net profits per loom, resulting from the improved lighting, very much more than covers the increased costs. These tests confirm the belief that the illumination at the front of the loom should be of the order of 20-30 lumens per sq. ft., and there are also points to be observed in connection with distribution and shadow. We note that a full account of the tests at Lothersdale (near Keighley) is to be issued in due course.

Improved Fluorescent Lamps

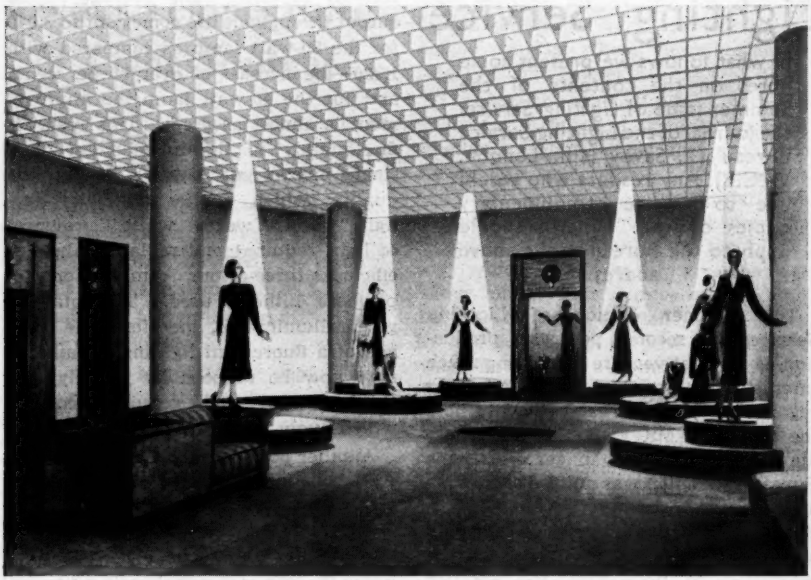
Lighting Service also contains some notes on fluorescent lamps, emphasising the substantial improvement in efficiency recently secured. The average lumen output throughout life comes out to 3,040 for the 80-watt lamp as compared with 1,920—an increase of over 50 per cent., and for the 40-watt lamp the improvement is almost as great. This result is due mainly to the introduction of a single fluorescent powder giving the quality (which applies alike to "daylight" and "warm white" colours) of light required and replacing the less efficient three-colour combinations of powders hitherto used. To obtain a given illumination, therefore, the wattage of a fluorescent lighting installation may now be reduced by roughly one-third—a real and genuine economy which ought to please Mr. Shinwell.

Another point, handled by Mr. A. D. S. Atkinson, is the suggestion of emission of ultra-violet radiation from fluorescent lamps—on which there has been much loose talk. The discharge itself does, in fact, contain strong radiation near 2,537 A.U., but such rays are almost completely absorbed by the glass envelope, so that the skin-tanning effect is probably only about 1-150th of that of daylight and with no appreciable biological effect. (Mr. Atkinson quotes from a letter inquiring whether working under fluorescent light tends to turn the hair white. The answer is that any kind of work under any kind of light is liable to do that!)

It is probable that in those few cases in which trouble from fluorescent lighting has been reported, this is due to misuse of the lamps. Their brightness, though low, does not entitle them to be used indiscriminately—especially now that, owing to the increased efficiency noted above, this brightness has been increased by 50 per cent.

The Attraction of Light

Elsewhere, under the title "Little Sir Dollar" there is a collection of views of those in the hotel and catering industry in regard to the generous use of



A sketch illustrating a new idea for future shop lighting—the use of a completely louvred ceiling which permits a combination of fluorescent lighting with supplementary spot lighting from filament lamps at specific points.

light, both inside and for show-windows. The conditions imposed by recent fuel cuts are depressing in the extreme and an obvious handicap to development. Of special interest is the impression made on visitors from abroad. Mr. F. J. Dawson, editor of the *Hotel Review*, emphasises the view that "London, as the capital of the Empire, must at some time in the future assess the value of lighting as an attraction to overseas visitors, and be prepared to spend some of our resources in this direction."

Shop Lighting

Finally, there is an instructive analysis, by Mr. F. Jamieson, of the problem of interior shop-lighting—and, in particular, of securing immediate improvements and yet keeping within the regulations. The improved output of light from the fluorescent lamp, and especially the latest variety, will help considerably towards getting the best out of the 1½ watts per sq. ft. at present permitted. There are also special devices and new ideas in regard to installation. of which the accompanying illustration is one example.

Reference is made to the fact that the Royal Society for the Prevention of Accidents is holding its Jubilee Congress in Brighton next October. One hopes that, if the question of domestic accidents is discussed, the part played by lighting in relation to safety will be emphasised.

Finally allusion is made to the recent activities of Mr. T. O. Freeth, who has aided in the holding of joint I.E.S.—E.A.W. meetings throughout the country. It is urged, however, that the interest of all types of organised women's groups, besides those professionally associated with lighting, should be sought.